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ABSTRACT

This study hypothesized that during high school men and women develop a belief about their competence in science that is based on their participation in certain science courses, their level of performance in those courses, and the effort that they expended. This sense of competence, in turn, affects the science decisions that these students make when they enter colleges, such that students who believe they have ability in science are more likely to choose a science curriculum and pursue a science career than those who do not. Results indicate that although women performed very well compared to men in high school biology and chemistry, their participation and performance in science relative to that of men declined after that point. Women felt that they had worked harder than men did in high school science courses, and they rated their ability lower, even though actual performance was generally better. Results also show that in a path model linking high school and college level variables, this sense of competence in science was a central variable. It is concluded that women's lower sense of competence in science is an important issue in their reduced participation in science courses and careers. (Author/JN)

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Sense of Competence in Science as a Factor in the Career Decisions of Men and Women

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Sense of Competence in Science as a Factor in the Career Decisions of Men and Women

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Abstract

It was hypothesized in this study that men and women develop a belief about their competence in science during the high school years that is based on their participation in certain science courses, their level of performance in those courses, and the effort that they expended. This sense of competence, in turn, affects the science decisions that these students make when they enter college. Students who believe they have ability in science are more likely to choose a science curriculum in college and pursue a science career than those who don't.

A comparison of men and women in the study showed that women performed very well compared to men in high school biology and chemistry. After that point, however, declines in their participation and performance in science relative to that of men were observed. Also, women felt they had worked harder than men did in high school science courses, but they rated their ability lower, even though actual performance was generally better. The results also showed that in a path model linking high school and college level variables, that this sense of competence in science was a central variable.

It was concluded that women's lower sense of competence in science is an important issue in their reduced participation in science courses and careers.

Almost twenty years ago, a paper by sociologist Alice Rossi (1965) appeared in Science and carried the title "Women in science: Why so few?" Whereas the limited participation of women in science was an important and legitimate concern in 1965, Rossi might just as well have asked why there were so few women in law, business, or college teaching. In that year, for example, only 367 law

degrees were conferred on women compared to over 11,000 for men (National Center for Education Statistics, 1982).

In attempting to explain the low participation rate of women in science, Rossi dealt in particular with social factors, expecially marriage and family, which inhibit the movement of women into life-long positions as physicians, dentists, engineers, and research scientists. She concluded that the priority of marriage and the interruption of career would continue to restrict women's participation in the top professional fields unless a good deal of social engineering took place, particularly with respect to child care and other domestic responsibilities.

Now, nineteen years later, we see that an enormous change has taken place in the career patterns of women. Women have broken virtually every employment barrier and entered the top professional fields as never before. In 1980, not 367, but almost 11,000 law degrees were conferred on women. The number of women graduating with business degrees is nearly equivalent to that of men and, if current trends continue, within a few years women will surpass men in the number of business degrees earned. In support of this prediction, the results of the 1983 College Board's Student Descriptive Questionnaire (SDQ), which is completed by high school seniors at the time they take the Scholastic Aptitude Test, showed that women now account for 57% of all intended business and commerce majors (Admissions Testing Program of the College Board, 1983).

Even in the science fields there have been improvements. For example, based on the College Board's 1983 SDQ results, there has been a steady narrowing of the gender gap in intended science careers and a substantial increase in the number of women taking physical science and mathematics courses in high school during the last decade (Admissions Testing Program of the College Board, 1983). But, whereas changes have taken place, gains have not been as rapid in science fields for women as in most other areas. Women are still less inclined to study science, especially physical science, in high school and college and to enter science careers after graduation from college. Clearly, social factors still play a major part in determining the career patterns of women--marriage and family still often interrupt women's career progress. But these factors play a part in both science and non-science career development. Why, then, has differential progress been made in science and non-science areas? Why are so many women going into business and law, two long-standing male preserves, and relatively few into positions as research chemists and engineers?

One variable that has been found to be related to achievement behaviors (including continued participation) is an individual's rating of his or her ability, i.e., one's personal sense of competence in an area. Covington and Omelich (1981) have argued that self-perception of ability is the most important causal factor in most achievement

behaviors. Self-worth theory (Beery, 1975; Covington & Beery, 1976) maintains that because of our society's tendency to equate achievement with human worth, a person's self-worth is threatened when the person does not feel capable of successful performance. Because of this, individuals do what they can to maintain and enhance their self-esteem. When they are successful, they tend to attribute that success to their ability. This makes them optimistic about their performance in similar situations that they might face in the future. When they are less successful, individuals protect their ego by attributing their lack of success to bad luck or too little effort. When failure is persistent, however, attribution to low ability becomes inevitable, and this produces low expectancy and participation (Covington & Omelich, 1981). Weiner (1980) has indicated that persons who believe they failed at an achievement task because of a lack of ability are less likely to persist at that task because a lack of ability is a stable characteristic of the person--one that will still be there the next time the task is attempted. There is also some evidence that suggests that women tend to devalue their performance and that of other women compared to the performance of men (Deaux & Farris, 1977; Goldberg, 1968). Such devaluing is indicative of lower self-confidence.

If women perceive themselves as being less competent in science than men, and if a sense of competence is an important causal factor in achievement behavior, this might

provide a partial explanation for women's lower participation in science courses and careers.

The purpose of the present study was to identify the differences between a group of men and women with respect to their career intentions, their self-ratings of ability, effort, luck, and task difficulty, and their performance and participation in high school and college science, and to test the hypothesis that a sense of competence is a critical variable in the science decisions that these students make. Specifically, it was hypothesized that men and women develop different beliefs about their competence in science prior to entering college. Sex differences in science competence ratings are based, in part, on differential participation in science courses in high school, performance differences in those courses, and differences in the effort that students had to expend. A sense of competence, in turn, affects the science decisions that these students make when they enter college. Students who believe they have ability in science are more likely to choose a science curriculum in college and pursue a science career than those who don't, even when actual science performance is held constant. In other words, it is being suggested that demonstrated competence in science is not sufficient. Perception of ability is an additional important element in career and course decisions.

To test this hypothesis, a set of academic variables from high school and college were examined for their interrelationships in a path model. The dependent variable was the intention of the students to pursue a career in science. The scientific careers that were included were dentistry, medicine, computer science, scientific research, and engineering.

Method

Data were taken from a sample of 302 juniors and seniors at a highly selective public university located in the Southeast who were taking an elective course in Human Growth and Development. This number represents 91% of the total enrollment in the course. Women comprised 59% of the class, just slightly more than the 56% in the college as a whole. Although not randomly selected, the students provided a good cross-section of the college. The students completed a two-page questionnaire in class that asked them about the science and mathematics courses they had taken in high school and college, including their self-ratings of ability, effort, luck, and task difficulty for each of these areas, and about their plans for the future. To obtain attributional ratings, students were asked to respond to the following items for each course area (1=strongly disagree, 5=strongly agree):

1. The courses were easy.
2. I worked very hard in these courses.
3. I have a lot of ability in this area.
4. I was very lucky in these courses.

Analysis of covariance was used to identify gender differences in attributions to ability, effort, luck, and task difficulty with course grades used as a covariate so that attributions for a common performance were being compared. Participation and performance of men and women were compared using t-tests and chi-square analysis. The causal sequences from high school to college were tested by means of path analysis in which standardized partial regression coefficients were calculated and used as path coefficients. Path coefficients between two variables in a system are measures of the direct effect of one of the variables on the other variable. The product of two successive path coefficients is a measure of the indirect effect of the first variable on the third variable, mediated by the second variable. Path coefficients are represented by numbers along single headed arrows in a path diagram. Numbers that appear beside two headed curvilinear arrows represent non-causal correlations between predetermined variables in the system. Further discussions of path analytic techniques can be found in Duncan (1975), Kim & Kohout (1975), and Land (1969).

Results

Table 1 contains several of the performance and participation measures on which men and women were compared. It is interesting to note that the women in this study

performed very well compared to men in both high school biology (men's GPA=3.60, women's GPA=3.73, t=2.61, p<.01) and in high school chemistry (men's GPA=3.37, women's GPA=3.64, t=3.82, p<.01), and that most of the women elected to take biology (men, 97%; women, 97%) and chemistry (men, 94%; women, 92%) in high school. After that point, however, the women took less science than the men and no longer performed at a higher level than the men.

Table 1

Comparison of the Performance and Participation of Men and Women

Variable	Men	Women
Scholastic Aptitude Test Scores		
Verbal	595	604
Math	636**	607
Participation in High School Science		
Years of Science	3.65**	3.28
Took Biology	97%	97%
Took Chemistry	94%	92%
Took Physics	76%**	57%
Performance in High School Science		
Biology Grade	3.60	3.73**
Chemistry Grade	3.37	3.64**
Physics Grade	3.53	3.59
Participation in College Science		
Biological Science Major	15%	11%
Physical Science Major	13%*	5%
Took at Least 1 Science Course	74%	74%
Took at Least 2 Science Courses	64%	58%
Took at Least 3 Science Courses	45%**	28%
Took at Least 4 Science Courses	40%**	22%
Number of Science Courses Taken	4.64**	3.28
Performance in College Science		
Biology Grades	2.68	2.67
Chemistry Grades	2.56	2.49
Total Science GPA	2.75	2.65

*p<.05, **p<.01

In Table 2 we see that the women felt they worked harder than the men in high school science courses (men, 3.04; women, 3.37; $F=5.73$, $p<.05$), and they rated their ability lower (men, 3.43; women, 3.08; $F=14.38$; $p<.01$), in spite of the fact that their actual performance through most of the high school years was better than that of the men.

Table 2

Analysis of Covariance Comparing Attributions for Success in High School Science for Men and Women

	Mean Attribution Ratings					
	Unadjusted		Adjusted		F-Ratios	
	Men	Women	Men	Women	Sex	Covariate
Task Ease	3.25	3.25	3.31	3.21	.61	12.24**
Effort	3.01	3.40	3.04	3.38	5.73*	5.23*
Ability	3.49	3.13	3.55	3.09	14.38**	10.06**
Luck	2.08	2.02	2.05	2.03	.03	1.78

Note. Combined grades in high school biology and chemistry were used as the covariate.
*$p<.05$
**$p<.01$

The science career plans of students appear in Table 3. Here we see that relatively small gender differences for each career area added to give a marginally significant difference for total science careers (men, 33.9%; women, 24.2%; $X^2=3.41$, $p=.06$). The intention of women to enter these careers may be overrated, however, because of their tendency to offer more career possibilities than the men, and this would make the science career interest of women

appear larger than it really is. This can be seen in Table 4 where the career areas that 10% or more of the science majors indicated they might be engaged in five years after graduation are listed. Men identified five likely careers for themselves whereas women listed ten careers, several of them outside of science, and, except for engineering, even the top five areas identified by the men were mentioned by the women more often than by the men. Clearly, the women were less certain of their career plans than were the men.

Table 3

Percentages of Male and Female College Students Who Expected to be Involved in Various Science Careers Five Years After Graduation from College

	Male	Female	X^2	p
Scientific Research	17.7	12.9	1.34	NS
Medical/Dental	11.3	9.0	.43	NS
Engineering	4.8	1.1	3.91	.05
Computer Science	8.1	9.0	.08	NS
Science Career Total	33.9	24.2	3.41	.06

Note. Students could respond to more than one item; therefore, percentages do not add to the science career total.

Table 4

Careers that Male and Female Science Majors Thought they would be Engaged in Five Years After College

Males (N=34)		Females (N=28)	
Career	%	Career	%
Scientific Research	55.9	Scientific Research	64.3
Medical/Dental	32.4	Medical/Dental	42.9
Engineer	14.7	Business	21.4
College Teaching	14.7	College Teaching	21.4
Secondary Teaching	11.8	Computer Science	17.9
		Secondary Teaching	14.3
		Performing Arts	14.3
		Med Tech/Nursing	10.7
		Elementary Teaching	10.7
		Literary/Editing	10.7

When examining the relationships between variables, the variables of most interest were those for which gender differences were present. In addition to the intention to enter a science career, which was the dependent variable in the study, other variables of interest were sex, SAT math scores, self-ratings of effort and ability, grades in high school biology and chemistry, number of high school science courses taken, and whether or not students majored in science in college. These variables were arranged into a causal sequence and the results tested by path analysis. Initial examination of the data showed that the presence of effort as a variable had little effect on the model and was, therefore, eliminated.

When the interrelationships between variables are presented in a path diagram (see Figure 1), the central position of a sense of competence can be seen. Rating of ability in science had a direct effect on both the decision to be a science major (P=.36, F=32.5, p<.01) and to enter a science career (P=.21, F=13.4, p<.01). Rating of ability also had an indirect effect on career selection through the decision to be a science major. A summary of direct, indirect, and total effects on each dependent variable appears in Table 5.

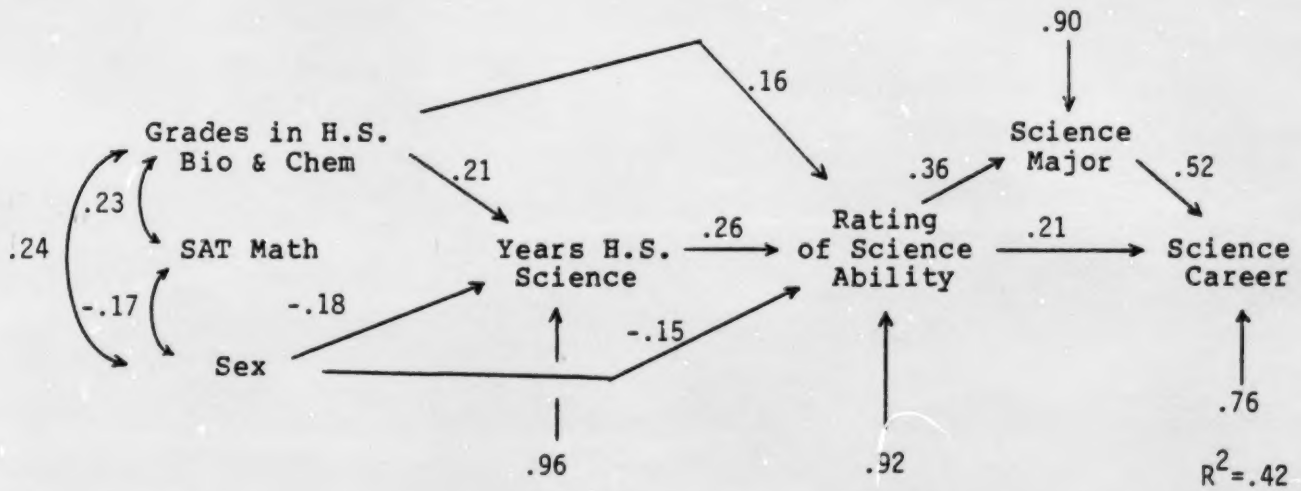

Figure 1. Path diagram for the causal model.

Table 5

Direct, Indirect, and Total Effects for the Causal model

Dependent Variable	Predetermined Variable	Direct Effect	Indirect Effect	Total Effect
Science Career	Science Major	.52	--	.52
	Rating of Ability	.21	.19	.40
	Years of H.S. Science	.01	.14	.15
	Grades in Bio & Chem	.02	.12	.14
	SAT Math	.04	.06	.10
	Sex	.01	-.13	.12
Science Major	Rating of Ability	.36	--	.36
	Years of H.S. Science	.08	.09	.17
	Grades in Bio & Chem	.06	.09	.15
	SAT Math	.05	.03	.08
	Sex	-.08	-.08	-.16
Rating of Ability	Years of H.S. Science	.26	--	.26
	Grades in Bio & Chem	.16	.05	.21
	SAT Math	.0	.02	.09
	Sex	-.15	-.05	-.20
Years of H.S. Science	Grades in Bio & Chem	.21	--	.21
	SAT Math	.07	--	.07
	Sex	-.18	--	-.18

Sense of competence was affected directly by the grades received in high school biology and chemistry (P=.16, F=5.73, p<.05) and the number of years of high school science (P=.26, F=18.27, p<.01). In addition, a gender difference in rating of ability remained (P= -.15, F=5.21, p<.05) even after high school science performance and participation were controlled. SAT math scores were not related to a sense of competence. Finally, the amount of science taken in high school, which had an important effect on the ratings of ability and which favored men, was

directly related to the grades received in previous science courses (P=.21, F=9.61, p<.01).

Discussion

This study identified a number of differences in the participation and performance of men and women in science, differences in their ratings of their science ability, and differences in their career intentions. As has been demonstrated many times before (see, for example, recent reports of the Admissions Testing Program of the College Board, e.g., Admissions Testing Program, 1983), fewer women intended to enter science careers than men. Also, women were less certain of their choice of a science career than men, even as juniors and seniors in college.

To a large extent, sex differences in career choices can be explained by sex differences in the students' rating of their ability in science. Students who rated their science ability higher were more likely to major in science and to anticipate a science career, and these differences in self-rating of ability favored men to a substantial degree.

Two factors were identified in this study as being related to differences in rating of ability. First, the more science courses students took in high school, the higher they rated their ability. Second, the higher the

grades the students received in those science courses, the more competent they felt. In addition, performance in early science courses was related to the number of science courses taken in high school.

Based on these relationships, a tentative causal sequence can be offered. High performance in science courses in high school (biology and chemistry) encourages students to take additional science courses in high school, especially physics. The greater the number of science courses taken and the higher the performance, the greater the feeling of competence. Finally, students who feel competent in science take science in college and plan to enter science careers. Given this sequence, we should expect to see more women than men taking science courses and entering science careers. Obviously, more is involved. For women, the sequence first breaks down when many of them decide not to take additional science courses in high school even though they did so well in earlier courses. It also breaks down for them when their participation and performance in high school science does not produce the same sense of competence in science that is developed in men. In other words, when participation and performance measures are controlled, a sex difference in rating of ability remains.

Why a sex difference in ability ratings remains is difficult to explain. Actual ability differences favoring men in this group are unlikely. The performance of the women in high school science would actually imply superior

ability on their part, and performance in college was at least on par with that of the men. SAT math scores were lower for women, and perhaps women's sense of competence was affected by these lower scores, but SAT math scores were only weakly related to other variables in the model. It may be that women felt less competent because they had to work harder for their success, but effort was also unrelated to other variables in the model.

Another possible explanation is that women form opinions about their competence in science because of the opinions that others have of the importance of their work. Devaluing the work of women, both by men and other women, even when that work is substantially the same as the work of men, has been demonstrated by several researchers (Deaux & Farris, 1977; Goldberg, 1968).

Regardless of its origins, the lower self-confidence that women have in their science ability seems to be an important issue and one that demands our attention. It seems particularly important that science educators encourage women to take as much science in high school as men take. For most college bound women this will mean taking physics in addition to biology and chemistry. Science educators must also do whatever they can to give high school and college women the recognition they deserve for their high academic performance. Their performance is at least equal to, and often superior to that of comparable groups of males (see Admissions Testing Program of the

College Board, 1983). Public acknowledgement of this fact might go a long way to increasing women's sense of competence in science.

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